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(54) Title: ENGINE LUBRICANT AND ADDITIVE

(57) Abstract: An engine lubricant formulated as a complete crankcase motor oil or additive concentrate composed of a combination of chemical constituents including a base oil selected from a synthetic oil, a mineral oil or semi-synthetic base oil (hydrogenated oil) or combination thereof, an oil soluble molybdenum additive, a dispersant inhibitor containing zinc dithiophosphate, and viscosity index improvers and one or more seal swelling agents to lubricate the engine and recondition the seals of new and/or high mileage engines. Addition of a polyalphaolefin and/or one or more esters such as a diester or polyolester may also be utilized therein. The lubricant may be formulated as a complete engine oil crankcase lubricant, or concentrated into an additive for addition to conventional mineral oil based engine oil, synthetic engine oils, or blends thereof in an effective amount of up to 30 percent volume percent, typically from 20 to 25 percent by volume.

ENGINE LUBRICANT AND ADDITIVE

TECHNICAL FIELD

The invention relates to the general field of an improved motor oil lubricant. The lubricant may be formulated as a 100% complete engine oil crankcase lubricant, or concentrated into an additive for addition to conventional mineral oil based engine oil, synthetic engine oils, or blends thereof in an effective amount of up to 30 percent volume percent, typical from 20 to 25 percent by volume. The invention is formulated to include selected seal swelling agents to recondition and maintain seals in new engines and/or more particularly high mileage engines.

DESCRIPTION OF THE PRIOR ART

Lubrication involves the process of friction reduction, accomplished by maintaining a film of a lubricant between surfaces which are moving with respect to each other. The lubricant prevents contact of the moving surfaces, thus greatly lowering the coefficient of friction. In addition to this function, the lubricant also can be called upon to perform heat removal, containment of contaminants, and other important functions. Additives have been developed to establish or enhance various properties of lubricants. Various additives which are used include viscosity improvers, detergents, dispersants, antioxidants, extreme pressure additives, and corrosion inhibitors.

Anti-wear agents, many of which function by a process of interactions with the surfaces, provide a chemical film which prevents metal-to-metal contact under high load conditions. Wear inhibitors which are useful under extremely high load conditions are frequently called "extreme pressure agents". Certain of these materials, however, must be used judiciously in certain applications due to their property of accelerating corrosion of metal parts, such as bearings. The instant invention utilizes

the synergy between several chemical constituents to provide an additive formula which enhance the performance of conventional engine oil and inhibits the undesirable side effects which may be attributable to use of one of more of the chemical constituents when used at particular concentrations.

Several references teach the use of individual chemical components to enhance the performance of conventional engine oil. For instance, U.S. 4,879,045 by Eggerichs adds lithium soap to a synthetic base oil comprising diester oil and polyalphaolefins which can comprise an aliphatic diester of a carboxylic acid such as di-2-Ethylhexylazelate, di-isodecyladipate, or ditridecyladipate, as set forth in the *Encyclopedia of Chemical Technology*, 34th addition, volume 14, pp 477-526, which describes lubricant additives including detergent-dispersant, viscosity index (VI) improvers, foam inhibitors, and the like.

SUMMARY OF THE INVENTION

The present invention comprises various formulations of an engine crankcase oil formula including selected seal swelling agents to recondition the rubber and elastomer components within the engine and includes a formula for an additive concentrates for addition to engine oil having a mineral oil base, a synthetic oil base, or blends thereof for improving the lubricating properties of the engine oil, enhance the performance of the engine, and reduce consumption of the oil.

One preferred embodiment of the engine crankcase lubricant and additive comprises a blend of chemical constituents including an oil soluble molybdenum additive, a dispersant inhibitor containing zinc dithiophosphate, and a viscosity index improvers in a synthetic, mineral oil, semi-synthetic hydrogenated base stock or combinations and blends thereof. An ester such as a diester, and/or a polyolester may be utilized therewith. A metal containing borate compound such as a borate ester or other compound may be added optionally as a corrosion inhibitor for

yellow metals. Alternate corrosion inhibitors may be selected from dimercapto, thiediapoles, or benztriazoles. The seal swelling compound is added to provide a formulation for use with older engines to aid in reconditioning and maintaining the seals. The constituents may be combined to give particular performance properties for formulating various embodiments of the lubricant additive concentrate for use with conventional crankcase engine oil or the formulation of a complete engine oil incorporating the additive concentrate package. The additive is used in an effective amount in combination with a conventional crankcase lubricant containing mineral oil, synthetic oil or combinations thereof up to about 30 percent by volume, more preferably from about 15 to 30 percent by volume, and most preferably from about 20 to about a 25% volume/percent.

The improved performance of the engine additive in comparison with conventional crankcase lubricants is attributable to optimizing the design parameters for each of the individual chemical constituents and combining the chemical constituents to obtain surprisingly good results including improved: wear, oxidation resistance, viscosity stability, engine cleanliness, fuel economy, cold starting, reduced oil consumption, and inhibition of acid formation. Additional components may be added to the engine additive formulation to enhance specific properties for special applications. Moreover, the formulation is compatible with engine warranty requirements.

The complete motor oil does not require the consumer to determine the amount of additive required for optional performance when blending with a conventional motor oil in small quantities between oil changes.

The individual components can be separately blended into the base fluid or can be blended therein in various subcombinations. Moreover, the components can be blended in the form of separate solutions in a diluent. Blending the components used in the form of an oil additive concentrate simplifies the blending

operations, reduces the likelihood of blending errors, and takes advantage of the compatibility and solubility characteristics afforded by the overall concentrate. Of course, the preblended complete motor oil is convenient to use and is often preferable for adding to an engine one quart or less at a time such as for routine maintenance of older cars having engine wear and requiring additional motor oil lubricant between oil changes.

The incorporation of hydrogenated oils which may be defined as mineral oil based synthetic oils processed to have special characteristics provide an means to reduce the cost of synthetic oils while maintaining many of the desirable characteristics. Finally, addition of seal swelling compounds in the precise proportions provides a means to lubricant, soften, and revitalize seals for reducing oil consumption and pollution generated thereby.

These lubricating compositions are effective in a variety of applications including crankcase lubricating oils for spark-ignited and compression-ignited internal combustion engines, two-cycle engines, aviation piston engines, marine and low-load diesel engines.

More particularly, a preferred concentrate for addition to conventional motor oil for improving the lubricating properties of the motor oil and enhancing the performance of the engine comprises the following chemical constituents: an oil soluble molybdenum additive, a mineral oil or semi-synthetic base oil having a selected viscosity, a Dispersant Inhibitor (DI) package containing zinc dithiophosphate (ZDP) and which may also contain a detergent and/or corrosion inhibitor, a viscosity index improver, and corrosion inhibitor. The addition of a seal swelling compound provides additional protection and increased performance characteristics.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention will be had upon reference to the following description in conjunction with the accompanying drawings in which like numerals refer to like parts throughout the several views and wherein:

Figure 1 is a graph showing reduced oil consumption using the motor oil composition of the present invention;

Figure 2 is a graph showing reduced engine deposits using the motor oil composition of the present invention;

Figure 3 is a graph showing the effect of oil on aged seal hardness;

Figure 4 is a graph showing the effect of oil thickening; and

Figure 5 is a graph showing the effects of minimum starting temperature of an formulated in accordance with the present invention..

DESCRIPTION OF THE PREFERRED EMBODIMENT

Each of the preferred ingredients of the synergistic engine treatment oil additive formulation, whether mandatory or optional, is discussed below:

OIL BASE STOCKS

The complete motor oil formula and/or the concentrated additive contains preferably up to 95 percent by volume, more preferably from about 10 to about 95 percent by volume, more preferably from about 25 to about 90 percent by volume, more preferably from about 40 to about 85% by volume, and most preferably from about 55 to 75 percent by volume of a base stock composed of a mineral oil, semi-synthetic oil, or a blend of a mineral oil or semi-synthetic oil with synthetic oil, and/or the

following base stocks defined as Group I (solvent refined mineral oils), Group II (hydrocracked mineral oils), Group III (severely hydrocracked oil); Group IV (polyolefins), and Group V (esters, and napthenes). Typically the base oils from Groups III, IV and V together with additives are deemed synthetic oils. As used in the instant application, oils from Group III are deemed semi-synthetic oils.

Synthetic lubricating oils include hydrocarbon oils and halo-substituted hydrocarbon oils such as polymerized and interpolymerized olefins (e.g., polybutylenes, polypropylenes, propylene-isobutylene copolymers, chlorinated polybutylenes, poly(1-octenes), poly(1-decenes), etc., and mixtures thereof; alkylbenzenes (e.g., dodecylbenzenes, tetradecylbenzenes, dinonylbenzenes, di-(2-ethylhexyl)benzenes, etc.); polyphenyls (e.g., biphenyls, terphenyls, alkylated polyphenyls, etc.), alkylated diphenyl, ethers and alkylated diphenyl sulfides and the derivatives, analogs and homologs thereof and the like.

Alkylene oxide polymers and interpolymers and derivatives thereof where the terminal hydroxyl groups have been modified by esterification, etherification, etc. constitute another class of known synthetic oils. These are exemplified by the oils prepared through polymerization of Ethylene oxide or propylene oxide, the alkyl and aryl ethers of these polyoxyalkylene polymers (e.g., ethylpolyisopropylene glycol either having an average molecular weight of 1000, diphenyl either of polyethylene glycol have a molecular weight of 500-1000, diethyl ether of polypropylene glycol having a molecular weight of 1000-1500, etc.) or mono- and polycarboxylic esters thereof, for example, the acetic acid esters, mixed C_3-C_8 fatty acid esters, esters, or the C_{13}0x0 acid diester of tetraethylene glycol.

Another suitable class of synthetic oils comprises the esters of dicarboxylic acids (e.g., phtalic acid, succinic acid, alkyl succinic acids and alkenyl succinic acids, maleic acid, azelaic acid, suberic acid, sebacic acid, fumaric acid, adipic

acid, alkenyl malonic acids, etc.) with a variety of alcohols (e.g., butyl alcohol, hexyl alcohol, dodecyl alcohol, 2-Ethylhexyl alcohol, Ethylene glycol diethylene glycol monoether, propylene glycol, etc.). Specific examples of these esters include dibutyl adipate, di(2-Ethylhexyl) sebacate, di-hexyl fumarate, dioctyl sebacate, diisooctyl azelate, diisodecyl azealate, dioctyl phthalate, didecyl phthalate, dicicosyl sebacate, the 2-Ethylhexyl diester of linoleic acid dimer, the complex ester formed by reacting one mole of sebacic acid with two moles of tetraethylene glycol and two moles of 2-Ethylhexanoic acid, and the like.

Esters useful as synthetic oils also include those made from C_5 to C_{12} monocarboxylic acids and polyols and polyol ethers such as neopentyl glycol, trimethylolpropane, pentaerythritol, dipentaerythritol, tripentaerythritol, etc. Other synthetic oils include liquid esters of phosphorus-containing acids (e.g., tricresyl phosphate, trioctyl phosphate, diethyl ester of decylphosphonic acid, etc.), polymeric tetrahydrofurans and the like.

Polyalphaolefin (PAO)

Although not essential, the preferred synthetic base stock comprises at least a significant portion of a polyalphaolefin. Polyalphaolefin, ("PAO"), is a synthetic fluid effective at high temperatures, such as occurs during operation of internal combustion engines. It is also very effective at low temperatures. It is especially effective in the presence of diesters. Polyalphaolefin provides superior oxidation and hydrolytic stability and high film strength. Polyalphaolefin also has a high molecular weight, higher flash point, higher fire point, lower volatility, higher viscosity index, and lower pour point than mineral oil. U.S. Patent 4,859,352 hereby incorporated by reference provides additional polyalphaolefin derivatives.

Preferred polyalphaolefins, ("PAO"), include those sold by MOBIL Chemical company as SHF fluids and those sold by ETHYL Corporation under the name ETHYLFLO, or ("ALBERMARLE"). PAO's include the ETHYL-FLOW series by ETHYL Corporation, "ALBERMARLE Corporation", including ETHYL-FLOW 162, 164, 166, 168, and 174, having varying viscosities from about 2 to about 460 centistoke. Also useful are blends of about 56% of the 460 centistoke product and about 44% of the 45 centistoke product as set forth in U.S. Patent 5,348,668 hereby incorporated by reference.

MOBIL SHF-42 from MOBIL Chemical Company, EMERY 3004 and 3006, and Quantum Chemical Company provide additional polyalphaolefins base stocks. For instance, EMERY 3004 polyalphaolefin has a viscosity of 3.86 centistokes (cSt) at 212 F. (100 C.) and 16.75 cSt at +104 F. (40 C.). It has a viscosity index of 125 and a pour point of -98 F and it also has a flash point of +432 F. and a fire point of +478 F. Moreover, EMERY 3006 polyalphaolefin has a viscosity of 5.88 cSt at +212 F. and 31.22 cSt at +104 F. It has a viscosity index of 135 and a pour point of -87 F. It also has a flash point of +464 F. and a fire point of +514 F. It has a molecular weight of 1450, a flash point of +550 F., and a fire point of +605F.

Additional satisfactory polyalphaolefins are those sold by Uniroyal Inc. under the brand SYNTON PAO-40, which is a 40 centistoke polyalphaolefin. Also useful are the ORONITE brand polyalphaolefins manufactured by CHEVRON Chemical Company.

It is contemplated that Gulf Synfluid 4 cSt PAO, commercially available from Gulf Oil Chemicals Company, a subsidiary of CHEVRON Corporation, which is similar in many respects to EMERY 3004 may also be utilized herein. MOBIL SHF-41 PAO, commercially available from MOBIL Chemical Corporation, is also similar in many respects to EMERY 3004.

Preferably the polyalphaolefins will have a viscosity in the range of about 2-10 centistoke at 100°C with viscosities of 4 and

6 centistoke being particularly preferred.

Moreover, a preferred embodiment may incorporate up to 95 percent by volume, more preferably from 10 to 90 percent by volume, and more preferably from about 40 to 85 percent by volume of polyalphaolefins having a viscosity of about 4cSt at 100°C such as is available from ETHYL Corporation under the trademark name of DURASYN 164.

A preferred concentrate embodiment may incorporate up to 95 percent by volume, more preferably from 5 to 85 percent by volume, more preferably from about 10 to 60 percent by volume, and most preferably from 10 to 30 percent by volume of polyalphaolefins having a viscosity of about 6cSt at 100°C such as is available from ETHYL Corporation under the trademark name of DURASYN 166.

Moreover, an even more preferred embodiment of the present invention further providing even more enhanced performance characteristics utilizes synthetics which include a specific portion comprising esters, polyesters, or combinations thereof. One preferred embodiment utilizes polyolefins as the synthetic base stock together with at least a portion comprising esters and/or polyesters.

Esters

The most preferred synthetic based oil ester additives are polyolesters and diesters such as di-aliphatic diesters of alkyl carboxylic acids such as di-2-Ethylhexylazelate, di-isodecyladipate, and di-tridecyladipate, commercially available under the brand name EMERY 2960 by EMERY Chemicals, described in U.S. Patent 4,859,352 to WAYNICK. Other suitable polyolesters are manufactured by MOBIL Oil. MOBIL polyolester P-43, M-045 containing two alcohols, and HATCO Corp. 2939 are particularly preferred.

Diesters and other synthetic oils have been used as replacements of mineral oil in fluid lubricants. Diesters have outstanding extreme low temperature flow properties and good residence to oxidative breakdown.

The diester oil may include an aliphatic diester of a dicarboxylic acid, or the diester oil can comprise a dialkyl aliphatic diester of an alkyl dicarboxylic acid, such as di-2-Ethyl hexyl azelate, di-isodecyl azelate, di-tridecyl azelate, di-isodecyl adipate, di-tridecyl adipate. For instance, Di-2-Ethyl hexyl azelate is commercially available under the brand name of EMERY 2958 by EMERY Chemicals.

Also useful are polyol esters such as EMERY 2935, 2936, and 2939 from EMERY Group of Henkel Corporation and HATCO 2352, 2962, 2925, 2938, 2939, 2970, 3178, and 4322 polyol esters from HATCO Corporation, described in U.S. 5,344,579 to Ohtani et al. and MOBIL ester P 24 from MOBIL Chemical Company. MOBIL esters such as made by reacting dicarboxylic acids, glycols, and either monobasic acids or monohydric alcohols like EMERY 2936 synthetic-lubricant base stocks from Quantum Chemical Corporation and MOBIL P 24 from MOBIL Chemical Company can be used. Polyol esters have good oxidation and hydrolytic stability. The polyol ester for use herein preferably has a pour point of about -100°C or lower to -40°C and a viscosity of about 2-460 centistoke at 100°C.

Although not essential, a preferred additive concentrate and/or motor oil comprises at least a portion of a ester. The concentrate additive and/or complete motor oil contains preferably up to 25 percent by volume, more preferably from about 5 to about 20 percent by volume, more preferably from about 5 to about 15 percent by volume, of a polyester or diester such as obtained from EMERY under the trademark 2960.

Hydrogenated ("Semi-Synthetic") Oils

A hydrogenated oil is a mineral oil subjected to

hydrogenation or hydrocracking under special conditions to remove undersirable chemical compositions and impurities resulting in a mineral oil based oil having synthetic oil components and properties. Typically the hydrogenated oil is defined as a group 3 petroleum based stock with a sulfur level less than 0.03 serverly hydrotreated and isodewaxed with saturates greater than or equal to 90 and a viscosity index of greater than or equal to 120 may optionally be utilized in amounts up to 90 percent by volume, more preferably from 5.0 to 50 percent by volume and more preferably from 20 to 40 percent by volume when used in combination with a synthetic or mineral oil.

The hydrogenated oil may be used as the sole base oil component of the instant invention providing superior performance to conventional motor oils with no other synthetic oil base or mineral oil base or used as a blend with mineral oil and/or synthetic oil. An example of such an oil is YUBASE-4. A complete motor oil or an additive concentrate embodiment may incorporate up to 95 percent by volume, more preferably from 5 to 85 percent by volume of the semi-synthetic as the oil base stock. When used in combination with another conventional synthetic oil such as those containing polyolefins or esters, or when used in combination with a mineral oil, the hydrogenated oil may be present in an amount of up to 95 percent by volume, more preferably from about 10 to 80 percent by volume, more preferably from 20 to 60 percent by volume and most preferably from 10 to 30 percent by volume of the base oil composition.

More particularly, the hydrogenated oil is a base oil for a lubricating oil consisting of a mineral oil and/or a synthetic oil, having a viscosity index of at least 110, and having a viscosity of from 2 to 50 CST at 100 degrees C. Hydrogenated oils can be obtained by subjecting raw materials for lubricating oils to hydrogenation treatment, using a hydrogenation catalyst such as cobalt or molybdenum with a silica-alumina carrier, and lubricating oil factions which can be obtained by the isomerization of waxes. The hydrocracked or wax-isomerized oils

contain 90 percent by weight of greater of saturates and 300 ppm or less of sulfur.

Mineral Oil Base Stock

Although not essential, a mineral oil base stock may be incorporated in the present invention as a portion of the concentrate or a base stock to which the concentrate may be added to produce a motor oil. Particularly preferred as mineral oil base stocks are the ASHLAND 325 Neutral defined as a solvent refined neutral having a SABOLT UNIVERSAL of 100 SUS @ 100°C and ASHLAND 100 Neutral defined as a solvent refined neutral having a SABOLT UNIVERSAL of 100 SUS @ 100°C, manufactured by the VALVOLINE Division of Ashland Inc., and by others.

Other acceptable petroleum-base fluid compositions include white mineral, paraffinic and MVI naphthenic oils having the viscosity range of about 20-400 Centistoke. Preferred white mineral oils include those available from WITCO Corporation, ARCO Chemical Company, PSI and PENRECO. Preferred paraffinic oils include solvent neutral oils available from EXXON Chemical Company, HVI neutral oils available from SHELL Chemical Company, and solvent treated neutral oils available from ARCO Chemical Company. Preferred MVI naphthenic oils include solvent extracted coastal pale oils available from EXXON Chemical Company, MVI extracted/acid treated oils available from SHELL Chemical Company, and naphthenic oils sold under the names HydroCal and CALSOL by CALUMET, and described in U.S. Patent 5,348,668 to Oldiges.

Mineral oil base stock can comprise up to 95% by volume, more preferably 5-85 percent by volume, more preferably 50-80 percent by volume and most preferably 70-80 percent by volume in the complete motor oil, but is not narrowly critical. More particularly the mineral oil base stock can optionally be used up to about 35 percent in the concentrate and up to 85 percent by volume of the motor engine oil.

Dispersant Inhibitor (DI)

Though not narrowly critical, the Dispersant Inhibitor ("DI"), is exemplified by those which contain alkyl zinc dithiophosphates, succinimide, or Mannich dispersant, calcium, magnesium, sulfonates, sodium sulfonates, phenolic and amine antioxidants, plus various friction modifiers such as sulfurized fatty acids. Dispersant inhibitors are readily available from LUBRIZOL, ETHYL, ORONITE, a division of CHEVRON Chemical, and PARAMAINS, a division of EXXON Chemical Company.

Generally acceptable are those commercial detergent inhibitor packages used in formulated engine oils meeting the API SHCD performance specifications. Particularly preferred are LUBRIZOL LZ8955 believed to contain at least one carboxylic derivative composition with at least one amine group, LUBRIZOL's LZ9802, ETHYL HITEC 1111 and 1131, and similar formulations available from PARAMAINS, a division of EXXON Chemical, or ORONITE, a division of CHEVRON Chemical. An effective amount of an additive packages which incorporate a dispersion inhibitor such as the one listed heretofore may also be utilized and include a conventional detergent and/or a corrosion inhibitor. Such an additive package may be utilized with or in substitution of a selected dispersion inhibitor or combinations thereof with each other and/or other dispersion inhibitors commercially available in an effective amount of up to 35 percent by volume, more preferably from about 0.5 to 25 percent by volume and more preferably from about 1 to 15 percent by volume of the complete motor oil formula and up to 6X that amount in the concentrate. The DI concentration is generally up to 15% by volume of the total formulation of the complete engine oil and more particularly from 5.0 to 15% by volume. Concentrations produced for dilution will generally be in these ranges.

Zinc dithiophosphate also functions as a corrosion inhibitor, antiwear agent, and antioxidants added to organic materials to retard oxidation.

Other metal dithiophosphates such as zinc isopropyl, methylamyl dithiophosphate, zinc isopropyl isooctyl dithiophosphate, barium di(nonyl) dithiophosphate, zinc di(cyclohexyl) dithiophosphate, copper di(isobutyl) dithiophosphate, calcium di(hexyl) dithiophosphate, zinc isobutyl isoamyl dithiophosphate, and zinc isopropyl secondary-butyl dithiophosphate may be applicable. These metal salts of phosphorus acid esters are typically prepared by reacting the metal base with the phosphorus acid ester such as set forth in U.S. Patent No. 5,354,485 hereby incorporated by reference. Moreover, a preferred dispersion inhibitor is described in United States Patent No. 5,490,945 hereby incorporated by reference which describes a compound containing at least one carboxylic derivative composition produced by reacting at least one substituted succinic acylating agent containing at least about 50 carbon atoms in the substituent with at least one amine compound containing at least one HN < group.

Pour Point Depressant

A pour point depressant in an effective amount of up to 10.0 volume percent of the complete engine oil formula and more preferably about .01 to 5.0 percent by weight and most preferably from about .1 to 1.0 percent by weight is utilized in an embodiment of the formulation. The additive would be concentrated in effective concentrations up to 5X of the amount of the complete motor oil formula. An example of a suitable pour point depressant is polymethacyrlate, alkylated bicyclic aromatics, styrene esters, polyfumerates, oligomerized alky phenols, dialkyl esters of phthalate acid, ethylene vinyl acetate copolymers, and other mixed hydrocarbon polymers from LUBRIZOL, ETHYL Corp.

Viscosity Index Improver (VI)

Viscosity improvers, ("VI"), include, but are not limited to, polyisobutenes, polymethacrylate acid esters, polyacrylate

acid esters, diene polymers, polyalkyl styrenes, alkenyl aryl conjugated diene copolymers, polyolefins and multifunctional viscosity improvers and SHELLVIS 90, a styrene-butadiene rubber in mineral oil base or SHELLVIS 260 a styrene isoprene compound.

Preferably the viscosity improvers will constitute up to 15 percent by volume, more preferably from about 0.05-10 percent by volume, more preferably 2 to 8 percent by volume of the complete motor oil formula and up to 5X that amount in the concentrate.

Seal Swelling Constituents

Seal swelling agents may be selected from aryl esters, alkly esters, vegetable based esters, sulfolanes, sulfolane derivitives, phenates, phthalate plasticizers like phthalate plasticizers, more particularly dioctyl phthalate, dinonly phthalate or dihexylpthalate, or other plasticizers. A seal swelling constituent such as a substituted sulfolane from LUBRIZOL, Inc., ETHYL Corp. can be used in an effective amount up to 1.0 volume percent, and more preferably from about 0.03 to 1.0 percent by weight of the complete motor oil formula and up to 5X that amount in the concentrate. Other seal swelling compositions including 3-alkoxysulfolane or the like, in which the alkoxy group contains at least about 4 and preferably about 4-25 carbon atoms, are described in U.S. Patents 4,029,587 and 4,116,877 hereby incorporated by reference.

The sulfolane compounds, are a preferred seal swelling component in the compositions of the instant invention.

Molybdenum Additive

A preferred molybdenum additive is an oil-soluble decomposable organo molybdenum compound, such as MOLYVAN 855, a non-phosphorus and non-sulfur molybdenum additive. In general, the organo molybdenum compounds are preferred because of their superior solubility and effectiveness. The combination of an

organic molybdenum compound provides significant improvements in the solubility and stability of the lubricant composition and additive concentrate not exhibited by inorganic molybdenum compounds.

A less effective alternative molybdenum additive is MOLYVAN L is sulfonated oxymolybdenum dialkyldithiophosphate described in U.S. Patent 5,055,174 by Howell hereby incorporated by reference.

MOLYVAN A made by R.T. Vanderbilt company, Inc., New York, New York, USA, is also an alternative additive which contains about 28.8 wt.% MO, 31.6 wt.% C, 5.4 wt.% H., and 25.9 wt.% S. Also useful are MOLYVAN 822, 856, and 807 in decreasing order of preference.

Also useful is SAKURA Lube-500, which is more soluble Mo dithiocarbamate containing lubricant additive obtained from Asahi Denki Corporation and comprised of about 20.2 wt.%MO, 43.8 wt.%C, 7.4 wt.%H, and 22.4 wt.%S.

Also useful is MOLYVAN 807, a mixture of about 50 wt.% molybdenum ditridecyldithyocarbonate, and about 50 wt.% of an aromatic oil having a specific gravity of about 38.4 SUS and containing about 4.6 wt.% molybdenum, also manufactured by R.T. Vanderbilt and marketed as an antioxidant and antiwear additive.

Other sources are molybdenum $Mo(Co)_6$, and Molybdenum octoate, $MoO(C_7H_{15}CO_2)_2$ containing about 8 weight-% Mo marketed by Aldrich Chemical Company, Milwaukee, Wisconsin and molybdenum naphthenethioctoate marketed by Shephard Chemical Company, Cincinnati, Ohio.

Inorganic molybdenum compounds such as molybdenum sulfide and molybdenum oxide are substantially less preferred than the organic compounds as described in 855, 822, 856, and 807. Most preferred are organic thio and phospho compounds such as those

typified by the Vanderbilt and other molybdenum compounds described specifically above are alternative selections.

The preferred dosage in the total lubricant is up to 5.0 percent by volume, more preferably from about 0.05 to about 5% by volume, more preferably from about 1.0 to about 3.0 percent by volume, and most preferably of from about 1.0 to 2.5 percent by volume molybdenum in the complete motor oil formula and up to 5X that amount in the concentrate.

CORROSION INHIBITORS

Borated Esters

Optionally, a boron antiwear/extreme pressure agent, preferably a borate ester is hydrolytically stable and is utilized for improved antiwear, antiweld, extreme pressure and/or friction properties, and perform as a rust and corrosion inhibitor for copper bearings and other metal engine components. The borated esters act as an inhibitor for corrosion of metal to prevent corrosion of either ferrous or non-ferrous metals (e.g. copper, bronze, brass, titanium, aluminum and the like) or both, present in concentrations in which they are effective in inhibiting corrosion.

Boron agents include boric acid, boric esters, acid borates and the like. Boron compounds include boron oxide, boric acid and esters of boric acid. Patents describing techniques for making basic salts of sulfonic, carboxylic acids and mixtures thereof include U.S. Patent Nos. 5,354,485; 2,501,731; 2,616,911; 2,777,874; 3,384,585; 3,320,162; 3,488,284; and 3,629,109. The disclosure of these patents are hereby incorporated by reference. Methods of preparing borated overbased compositions are found in U.S. Patent Nos.: 4,744,920; 4,792,410; and PCT publication WO 88/03144. The disclosure of these references are hereby incorporated by reference. The oil-soluble neutral or basic salts of alkali or alkaline earth metals salts may also be reacted with a boron compound.

A borate ester is a preferred boron compound utilized in the preferred embodiment which is manufactured by MOBIL Chemical Company under the product designation of ("MCP 1286") and MOBIL ADC700. Test data show the viscosity at 100°C using the D-445 method is 2.9 cSt; the viscosity at 40°C using the D-445 method is 11.9; the flash point using the D-93 method is 146; the pour point using the D-97 method is -69; and the percent boron as determined by the ICP method is 5.3%.

The preferred dosage of boron containing metal in the total crankcase lubricant in an effective amount of up to 10.0 volume percent, more preferably from about 0.01 to about 10.0 volume %, more preferably from about 0.01 to about 5 volume %, and most preferably from about 0.1-3.0 volume percent in the complete engine oil formula and about 5X that amount in the concentrate.

The oil additive formulation containing borate ester was found to comply with all requirements of engine additives specification CRC L-38 for a Crankcase Oxidation Test showing the Total Adjusted Bearing Weight Loss comparing the synergistic blend of Components comprising the oil additive with an API SG 5W-30 Motor Oil.

The invention also contemplates the use of other additives in the lubricating and functional fluid compositions of this invention. Such additives include, for example, detergents and dispersants of the ash-producing or ashless type, corrosion and oxidation-inhibiting agents, pour point depressing agents, auxiliary extreme pressure and/or antiwear agents, color stabilizers and anti-foam agents.

Other corrosion resisting compounds which may be used together with boron or independently may be selected from the group comprising dimercapto, thiediapoles, and benzotriazoles, benzotriazole derivatives, benzothiazole, benzothiazole derivatives, triazole, triazole derivatives, benzoimidazole, and benzoiidazole derivitives. The preferred dosage of corrosion

protection components in the total crankcase lubricant in an effective amount of up to 10.0 volume percent, more preferably from about 0.001 to about 10.0 volume percent, more preferably from about 0.01 to about 5 volume percent, and most preferably from about 0.1-3.0 volume percent in the complete engine oil formula and about 3-6X that amount in a concentrate.

CRANKCASE MOTOR OIL EXAMPLES

A better understanding of the present invention will be had upon reference to the following examples set forth in Tables I - VI (Formulas A-E) setting forth the compositions of complete crankcase motor oil formulas:

TABLE I

Test	SAE 5W-30	SAE 10W-30	SAE 10W-40	SAE 20W-50
Vis @ 100°C (cSt)	10.6	10.5	13.5	17.4
Spec Gravity @ 60°F	0.8655	0.878	0.877	0.8842
Density (lbs/gal)	7.206	7.323	7.305	7.364
Flash COC (°C)	221	230	242	245
Pour Point (°C) max	-39	-39	-39	-39
CCS cP (°C)	2300 @ -25C	2340 @ -20C	2600 @ -20C	2700 @ -10C
MRV TP-1 cP (°C)	17,812 @-35C	14,361 @ -30C	20,850 @ -30C	22,340 @ -20C
HTHS, cP	3.05	3.1	3.5	4.5
Noack (%) max wt. Loss	14.0	14.0	14.1	-
Zinc/Phosphorus (wt%)	0.119/0.1	0.119/0.1	0.119/0.1	0.119/0.1
Calcium/Magnesium (wt%)	0.09/0.036	0.09/0.036	0.09/0.036	0.09/0.036

Table I provides the technical specifications showing the present invention in accordance with the Formula A in different weights exceeds the engineer performance requirements of API SJ, SH, SG, SF and previous gasoline categories.

TABLE II

FORMULA "A"

Complete Engine Oil Formula

Components	Vol %	Range (vol%)
Polyalphaolefin Base Stock	17.38	1-90
Ester Base Stock	2.44	1-90
Mineral Oil Base Stock	27.93	1-90
Group III (severely hydrocracked semi-synthetic oil) Base Stock	32.97	1-90
LZ8955 Dispersant Inhibitor	3.14	0.5-35
LZ 9802 Dispersant Inhibitor	7.90	0.5-35
Substituted Sulfolane Seal Sweller	0.25	0.05-10
Oil-soluble Molybdenum Additive	0.46	0.05-10
Styrene isoprene Viscosity Index Improver	6.92	0.5-15
Boric acid Compound Corrosion Inhibitor	0.28	0.05-5
Poly-methacyrlate Pour Point Depressant	0.33	0.05-5
	100.00	

TABLE III

FORMULA "B"

Complete Engine Oil Formula

Components	Vol %	Range (vol%)
Polyalphaolefin Base Stock and /or Ester Base Stock and/or Mineral Oil Base Stock and/or Group III (Severely Hydrocracked Semi-synthetic Oil) Base Stock	80.72	5-90
LZ8955 Dispersant Inhibitor	3.14	0.5-35
LZ 9802 Dispersant Inhibitor	7.90	0.5-35
Sulfolane Compound	0.25	0.05-10
Oil-soluble Molybdenum Additive	0.46	0.05-10
Styrene isoprene Viscosity Index Improver	6.92	0.5-15
Boric acid Compound Corrosion Inhibitor	0.28	0.05-5
Poly-methacyrlate Pour Point Depressant	0.33	0.05-5
	100.00	

TABLE IV

FORMULA "C"

Complete Engine Oil Formula

Components	Vol %	Range (vol%)
Group I (solvent refined mineral oils) and/or Group II (hydrocracked mineral oils) and/or Group III (severely hydrocracked oil) and/or Group IV Synthetics including (polyolefins) and /or Group V Synthetics (esters, and napthenes)	80.72	5-90
LZ8955 Dispersant Inhibitor	3.14	0.5-35
LZ 9802 Dispersant Inhibitor	7.90	0.5-35
Substituted Sulfolane Seal Sweller	0.25	0.05-10
Oil-soluble Molybdenum Additive	0.46	0.05-10
Styrene isoprene Viscosity Index Improver	6.92	0.5-15
Boric acid Compound Corrosion Inhibitor	0.28	0.05-5
Poly-methacyrlate Pour Point Depressant	0.33	0.05-5
	100.00	

TABLE V

FORMULA "D"

Complete Engine Oil Formula

Components	Vol %	Range (vol%)
Group I (solvent refined mineral oils) and/or Group II (hydrocracked mineral oils) and/or Group III (severely hydrocracked oil) and/or Group IV Synthetics including (polyolefins) and /or Group V Synthetics (esters, and napthenes)	80.72	5-90
Dispersant Inhibitor	11.04	0.5-35
Substituted Sulfolane	0.25	0.05-10
Oil-soluble Molybdenum Additive	0.46	0.05-10
Viscosity Index Improver	6.92	0.5-15
Corrosion Inhibitor	0.28	0.05-5
Pour Point Depressant	0.33	0.05-5
	100.00	

TABLE VI

FORMULA "E"

Complete Engine Oil Formula

Components	Vol %	Range (vol%)
Group I (solvent refined mineral oils) and/or Group II (hydrocracked mineral oils) and/or Group III (severely hydrocracked oil) and/or Group IV Synthetics including (polyolefins) and /or Group V Synthetics (esters, and napthenes) Base Oil	80.72	5-90
A Dispersant Inhibitor	11.04	0.5-35
Substituted Sulfolane and/or phthalate plasticizer and/or dinonly phthalate plasticizer and/or dihexylpthalate plasticizer, and/or, sulfolane and/or a Substituted Sulfolane Seal Sweller	0.25	0.05-10
An oil-soluble Organo Molybdenum and/or sulfonated oxymolybdenum dialkyldithiophosphate, and/or molybdenum dithiocarbamate and/or molybdenum octoage and/or molybdenum sulfide and/or molybdenum oxide	0.46	0.05-10
A polyisobutenes and/or polymethacrylate Acid Esters and/or Diene Polymers and/or Polyolefins and multifunctional viscosity improvers and/or styrene-butadiene rubber in mineral oil and/or A styrene iosprene Viscosity Index Improver	6.92	0.1-15
Borate Ester and/or a Dimercapto and/or a Thiediapoles and/or a Benzotriazole Corrosion Inhibitor	0.28	0.01-5
A polymethacyrlate, alkylated bicyclic aromatics, styrene esters, polyfumerates, oligomerized alky phenols, dialkyl esters of phthalate acid, ethylene vinyl acetate copolymers, and other mixed hydrocarbon polymers Pour Point Depressant	0.33	0.05-5
	100.00	

CONCENTRATED ADDITIVES EXAMPLES

A better understanding of the present invention will be had upon reference to the following examples set forth in Tables VI - XI (Formulas F-J) setting forth the compositions of concentrated additives for use with conventional synthetic, mineral oil, or

blended motor oils at up to 30% by volume crankcase motor oil.

TABLE VII

FORMULA "F"

Concentrated Additive Formula

Components	Vol %	Range (vol%)
Polyalphaolefin Base Stock	17.38	1-90
Ester Base Stock	2.44	1-90
Mineral Oil Base Stock	24.96	1-90
Group III (severely hydrocracked semi-synthetic oil) Base Stock	32.97	1-90
LZ8955 Dispersant Inhibitor	3.14	0.5-35
LZ 9802 Dispersant Inhibitor	7.90	0.5-35
Substituted Sulfolane Seal Sweller	1.00	0.05-10
Oil-soluble Molybdenum Additive	1.84	0.05-10
Styrene isoprene Viscosity Index Improver	6.92	0.5-15
Boric acid Compound Corrosion Inhibitor	1.12	0.05-5
Poly-methacyrlate Pour Point Depressant	0.33	0.05-5
	100.00	

TABLE VIII

FORMULA "G"

Concentrated Additive Formula

Components	Vol %	Range (vol%)
Polyalphaolefin Base Stock and /or Ester Base Stock and/or Mineral Oil Base Stock and/or Group III (Severely Hydrocracked Semi-synthetic Oil) Base Stock	77.75	5-90
LZ8955 Dispersant Inhibitor	3.14	0.5-35
LZ 9802 Dispersant Inhibitor	7.90	0.5-35
Pheanate Seal Sweller	1.00	0.05-10
Oil-soluble Molybdenum Additive	1.84	0.05-10
Styrene isoprene Viscosity Index Improver	6.92	0.5-15
Boric acid Compound Corrosion Inhibitor	1.12	0.05-5
Poly-methacyrlate Pour Point Depressant	0.33	0.05-5
	100.00	

TABLE IX

FORMULA "H"

Concentrated Additive Formula

Components	Vol %	Range (vol%)
Group I (solvent refined mineral oils) and/or Group II (hydrocracked mineral oils) and/or Group III (severely hydrocracked oil) and/or Group IV Synthetics including (polyolefins) and /or Group V Synthetics (esters, and napthenes)	77.75	5-90
LZ8955 Dispersant Inhibitor	3.14	0.5-35
LZ 9802 Dispersant Inhibitor	7.90	0.5-35
Substituted Sulfolane Seal Sweller	1.00	0.05-10
Oil-soluble Molybdenum Additive	1.84	0.05-10
Styrene isoprene Viscosity Index Improver	6.92	0.5-15
Boric acid Compound Corrosion Inhibitor	1.12	0.05-5
Poly-methacyrlate Pour Point Depressant	0.33	0.05-5
	100.00	

TABLE X

FORMULA "I"

Concentrated Additive Formula

Components	Vol %	Range (vol%)
Group I (solvent refined mineral oils) and/or Group II (hydrocracked mineral oils) and/or Group III (severely hydrocracked oil) and/or Group IV Synthetics including (polyolefins) and /or Group V Synthetics (esters, and napthenes)	77.75	5-90
Dispersant Inhibitor	11.04	0.5-35
Substituted Sulfolane	1.00	0.05-10
Oil-soluble Molybdenum Additive	1.84	0.05-10
Viscosity Index Improver	6.92	0.5-15
Corrosion Inhibitor	1.12	0.05-5
Pour Point Depressant	0.33	0.05-5
	100.00	

TABLE XI

FORMULA "J"

Concentrated Additive Formula

Components	Vol %	Range (vol%)
Group I (solvent refined mineral oils) and/or Group II (hydrocracked mineral oils) and/or Group III (severely hydrocracked oil) and/or Group IV Synthetics including (polyolefins) and /or Group V Synthetics (esters, and napthenes) Base Oil	77.75	5-90
At least one Dispersant Inhibitor	11.04	0.5-35
Substituted Sulfolane and/or phthalate plasticizer and/or dinonly phthalate plasticizer and/or dihexylpthalate plasticizer, and/or, sulfolane and/or a Substituted Sulfolane Seal Sweller	1.00	0.05-10
An oil-soluble Organo Molybdenum and/or sulfonated oxymolybdenum dialkyldithiophosphate, and/or molybdenum dithiocarbamate and/or molybdenum octoage and/or molybdenum sulfide and/or molybdenum oxide	1.84	0.05-10
A polyisobutenes and/or polymethacrylate Acid Esters and/or Diene Polymers and/or Polyolefins and multifunctional viscosity improvers and/or styrene-butadiene rubber in mineral oil and/or A styrene iosprene Viscosity Index Improver	6.92	0.1-15
Borate Ester and/or a Dimercapto and/or a Thiediapoles and/or a Benzotriazole Corrosion Inhibitor	1.12	0.01-5
A polymethacyrlate, alkylated bicyclic aromatics, styrene esters, polyfumerates, oligomerized alky phenols, dialkyl esters of phthalate acid, ethylene vinyl acetate copolymers, and other mixed hydrocarbon polymers Pour Point Depressant	0.33	0.05-5
	100.00	

EXPERIMENTAL RESULTS

As best illustrated in the drawings, Figure 1 shows the present invention as set forth in Formula A exhibits superior oil consumption performance when tested in a new 2000 Buck 3.8L engine under extreme highway driving conditions. Improved performance was also exhibited after the engine was aged with conventional oil, then switched to the Formula A composition. The results were verified by running actual cars on a dynamometer.

Figure 2 shows improved deposit control properties as compared to a conventional oil when tested in a new 2000 Buick 3.8 L engine under extreme highway driving conditions. Improved performance was also exhibited after the engine was aged with conventional oil, then switched to the Formula A composition.

Figure 3 is a graph showing the seal conditioning properties of the composition of Formula A. The seal performance tends to deteriorate with use and aging. They tend to harden or soften affecting their performance. In the test results shown in Figure 3, the seals were treated with conventional oil at elevated temperatures over a period of time causing them to harden/soften. Formula A, as shown above, has a greater ability to bring the seals to their original state (desired hardness) as compared to conventional oils.

As shown in the graph depicted in Figure 4, oil thickening occurs due to oil tending to oxidize and thicken with age. The oil should resisting thermal breakdown and exhibit good viscosity control. As shown in the graph, the Formula A composition developed with unique additives slow down the oxidation process reducing oil thickening.

Figure 5 shows a graph whereby Formula A is formulated with premium base stocks having superior low temperature properties as

compared to conventional oils enabling the engine to start at lower temperatures, within the specified limits of it's viscosity grade. Of course, for the lowest starting temperature use Formula in the 5W-30 weight.

EXPERIMENTAL EVALUATION

The foregoing Examples provide the results of tests performed comparing the synergistic combination of formula components of the present invention with conventional motor oil having a synthetic, mineral oil, or blend base. The Examples exemplify the technology previously described. The synergistic combination of the formula components in the Examples provide excellent performance at high temperatures while also maintaining excellent performance at moderately elevated temperatures and normal temperatures, as well as provide resistance to ferrous and copper corrosion, improved wear, oxidation resistance, viscosity stability, engine cleanliness, fuel economy, cold starting, inhibition of acid formation, and other desirable high performance properties greater than exhibited by the individual components. The improved performance of the engine additive in comparison with conventional mineral oil crankcase lubricants is attributable to optimizing the design parameters for each of the individual chemical constituents and combining the chemical constituents according to the present invention.

Modifications

Specific compositions, methods, or embodiments discussed are intended to be only illustrative of the invention disclosed by this specification. Variation on these compositions, methods, or embodiments are readily apparent to a person of skill in the art based upon the teachings of this specification and are therefore intended to be included as part of the inventions disclosed herein.

Reference to documents made in the specification is intended to result in such patents or literature cited are expressly incorporated herein by reference, including any patents or other literature references cited within such documents as if fully set forth in this specification.

The foregoing detailed description is given primarily for clearness of understanding and no unnecessary limitations are to be understood therefrom, for modification will become obvious to those skilled in the art upon reading this disclosure and may be made upon departing from the spirit of the invention and scope of the appended claims. Accordingly, this invention is not intended to be limited by the specific exemplifications presented hereinabove. Rather, what is intended to be covered is within the spirit and scope of the appended claims.

CLAIMS

We claim:

Claim 1. An engine crankcase lubricant, comprising:

an effective amount of a base oil selected from the group consisting of Group I solvent refined mineral oils, Group II hydrocracked mineral oils, Group III serverly hydrocracked oils or combinations thereof;

an effective amount of a synthetic base oil selected from Group IV synthetic polyolefins, Group V synthetic oils comprising esters and napthenes, or combinations thereof;

an effective amount of a dispersant inhibitor;

an effective amount of a seal swelling agent selected from the group consisting of substituted sulfolane, phthalate plasticizer, dinonly phthalate plasticizer, dihexylpthalate plasticizer, sulfolanes, phenates, and combinations thereof;

an effective amount of a molybdate compound selected from the group consisting of an oil soluble organo molybdenum, a sulfonated oxymolybdenum dialkydithiophosphate, a molybdenum dithiocarbamate, a molybdenum octoage, a molybdenum sulfide, and a molybdenum oxide;

an effective amount of a viscosity improver selected from the group consisting of a polyisobutene, a polymethacrylate acid esters, a diene polymer, a polyolefin, a multifunctional viscosity diene polymer, a polyolefin and multifunctional viscosity improver, a styrene-butadiene rubber in mineral oil, a styrene iosprene viscosity improver, and combinations thereof;

an effective amount of a corrosion inhibitor selected from the group consisting of a borate ester, a dimercapto, a thiediapoles, a benzotriazole a benzotriazole, a triazole and combinations thereof; and

an effective amount of a pour point depressant selected from the group consisting of a polymethacyrlate, an alkylated bicyclic aromatic, a styrene ester, a polyfumerate, an oligomerized alkyl phenol, a dialky ester of phthalate acid, an ethylene vinyl acetate copolymer, and other mixed hydrocarbon polymers.

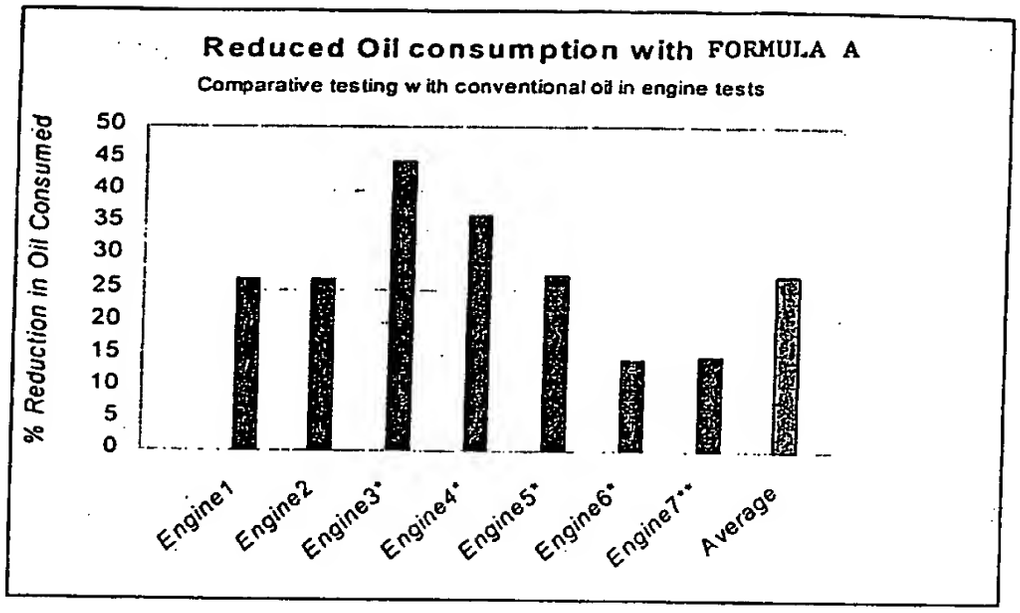

Figure 1

Reduced Oil Consumption: Formula A showed superior oil consumption performance when tested in a new Buick 3.8L engine under extreme highway driving conditions. *Improved performance was also exhibited after the engine was aged with conventional oil, then switched to Formula A. **These results were verified by running actual cars on a dynamometer.

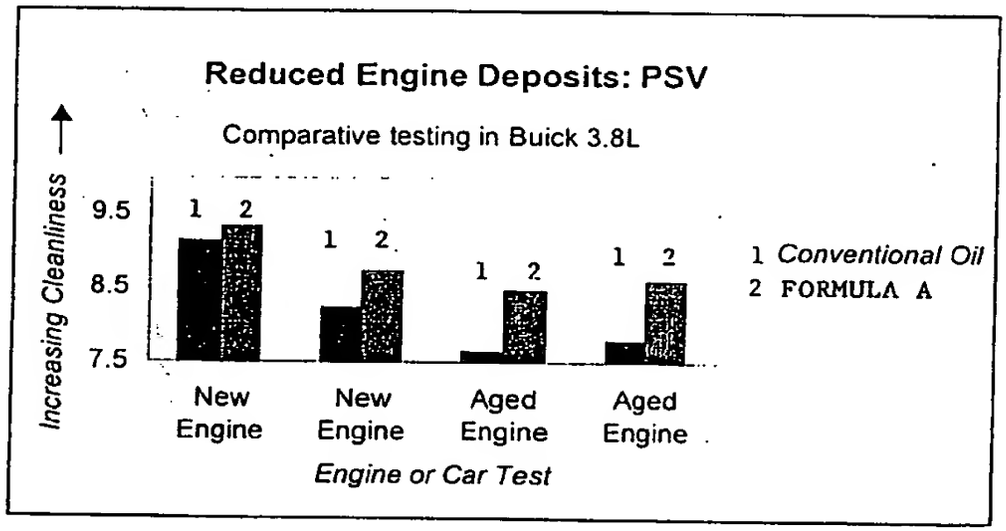

Figure 2

Reduced Engine Deposits: Formula A showed improved deposit control properties as compared to a conventional oil when tested in a new Buick 3.8L engine under extreme highway driving conditions. Improved performance was also exhibited after the engine was aged with conventional oil, then switched to Formula A.

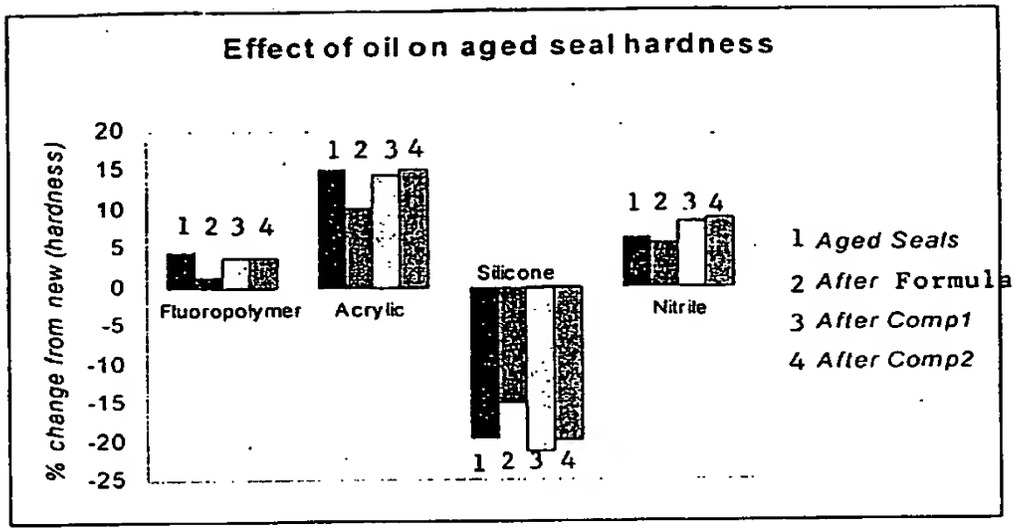

Figure 3

Seal Conditioning: Seal performance tends to deteriorate with use and aging. They tend to harden or soften affecting their performance. In the above test, seals were treated with conventional oil at elevated temperatures over a period of time causing them to harden/soften. Formula A, as shown above, has a greater ability to bring the seals to their original state (hardness) as compared to conventional oils.

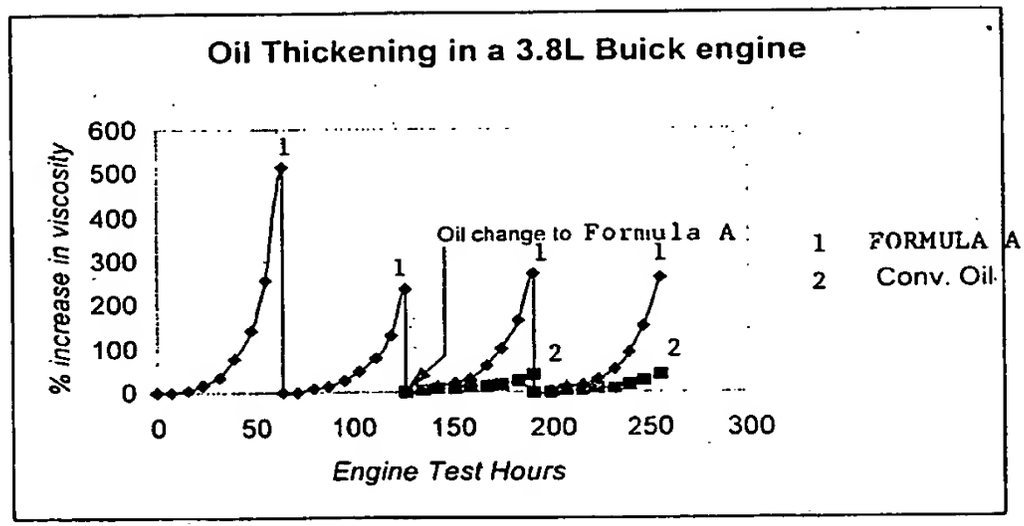

Figure 4

Resisting thermal breakdown and good viscosity control: Oil tends to oxidize and thicken with age. Formula A is formulated with unique additives that slow down the oxidation process, which reduces oil thickening.

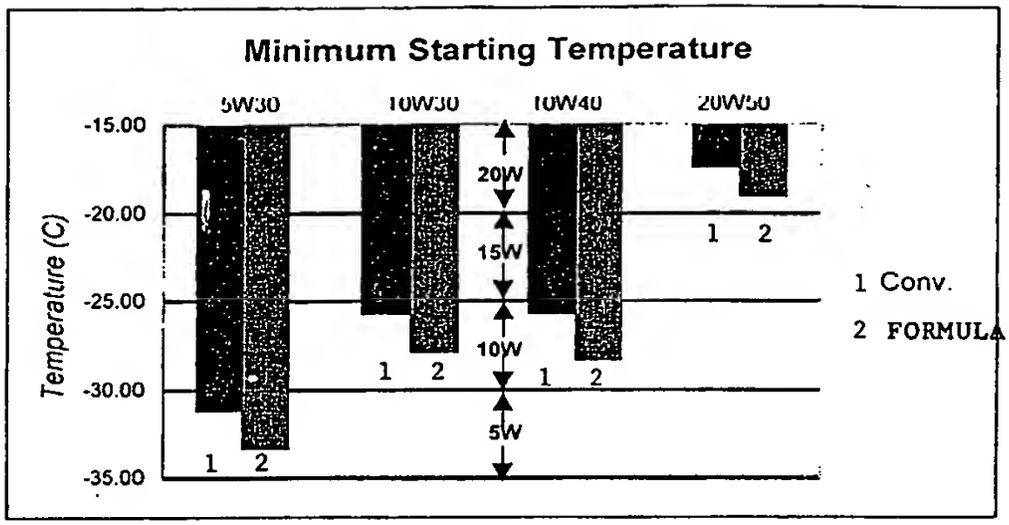

Figure 5

Easier Cold Start: Formula A which is formulated with premium base stocks has superior low temperature properties as compared to conventional oils enabling the engine to start at lower temperatures, within the specified limits of it's viscosity grade. For the lowest starting temperature use Formula A 5W-30.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/32167

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : C10M 169/04, 161/00, 141/12
US CL : 508/165, 167, 185, 280, 371, 591

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 508/165, 167, 185, 280, 371, 591

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,696,964 A (CUSUMANO et al(09 December 1997, column 41, line 1 to column 61, line 21.	1
Y	SMALHEER et al., Lubricant Additives, 1967, pages 1-11.	1

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
03 May 2002 (03.05.2002)

Date of mailing of the international search report
12 JUN 2002

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Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/32167

Continuation of B. FIELDS SEARCHED Item 3:

EAST

search terms: molybdenum or oxymolybdenum, seal with swelling, corrosion with inhibitor, phthalate, dispersant, vi, corrosion, with pour point.